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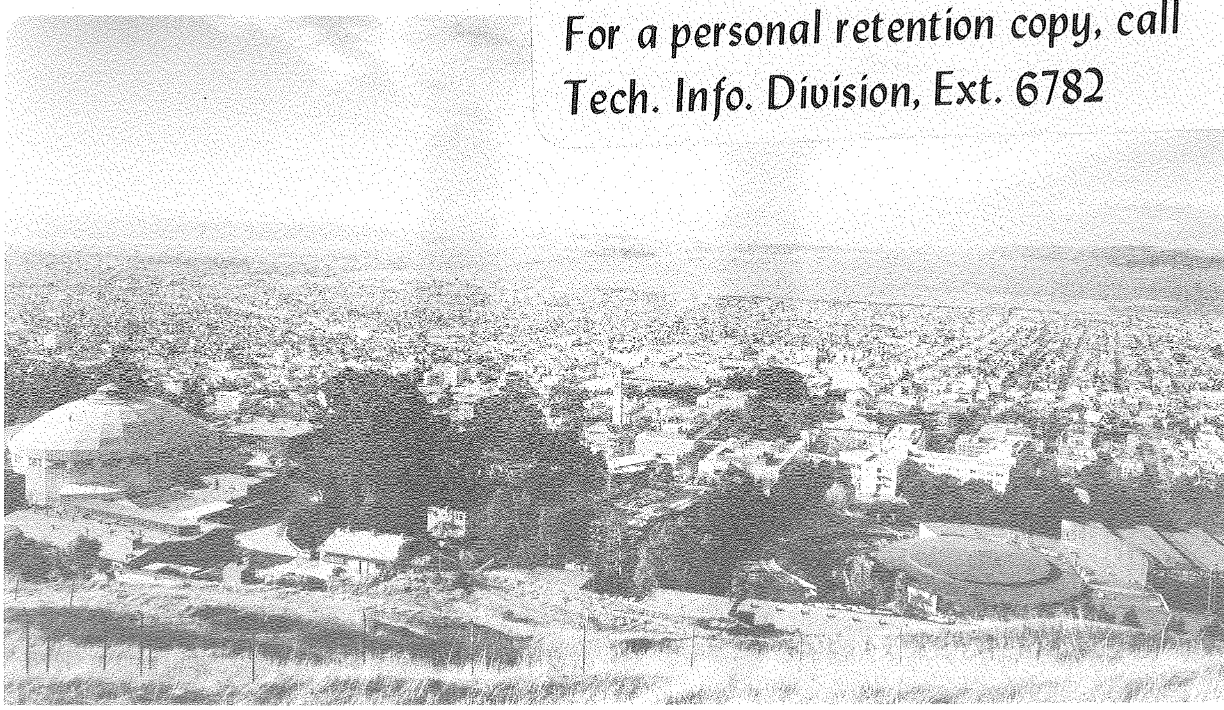

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ACQUISITION AND PREPARATION OF SPECIMENS OF ROCK FOR LARGE-SCALE TESTING

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Abstract. The techniques used for acquisition and preparation of large specimens of rock for laboratory testing depend upon the location of the specimen, the type of rock and the equipment available at the sampling site. Examples are presented to illustrate sampling and preparation techniques used for two large cylindrical samples of granitic material, one pervasively fractured and one containing a single fracture.

Introduction

The acquisition and preparation of specimens represents a significant portion of the cost and effort involved in large-scale laboratory tests on rock. For the purpose of this discussion, the term "large" will be assumed to apply to specimens of rock with principal dimensions on the order of one meter. Within this class, typical cylindrical specimens have diameters within the range of 0.5 to 2.0 m and lengths between 1.5 and 3.0 times the diameter. Joint and discontinuity surfaces contained within prismoidal samples have areas on the order of 0.25 to 1.5 m^2. Large specimens will usually have to be selected individually because the procedures used are frequently controlled by such factors as rock-type, accessibility, the type of cutting equipment available and the characteristics of the testing equipment and laboratory support facilities. Table 1 summarizes the principal specimen types and the laboratory tests that can be performed using these specimens.

TABLE 1. PRINCIPAL TYPES OF LARGE ROCK SPECIMENS AND LABORATORY TESTS

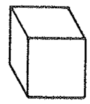
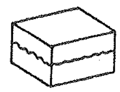
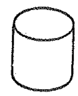
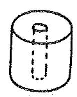
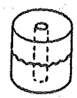
SPECIMEN		TYPICAL TEST APPLICATION
CUBIC		CONSTITUTIVE PROPERTIES IN THREE-DIMENSIONAL STRESS STATE (TRULY TRIAXIAL TESTS)
RECTANGULAR PRISM (JOINTED ROCK)		DIRECT SHEAR TESTS, SHEAR STRENGTH AND DEFORMABILITY OF JOINTS AND FRACTURES, FRACTURE CONDUCTIVITY
INTACT CYLINDER		TRIAXIAL TESTS, STRENGTH AND CONSTITUTIVE PROPERTIES OF ROCK MATRIX, THERMO-MECHANICAL PROPERTIES
INTACT CYLINDER WITH AXIAL BOREHOLE		MATRIX PERMEABILITY, HYDRAULIC FRACTURING, DOWNHOLE GEOPHYSICS
CYLINDER WITH DISCRETE FRACTURE NORMAL TO AXIS AND AXIAL BOREHOLE		FRACTURE CONDUCTIVITY, FRACTURE CLOSURE (NORMAL STRESS)
CYLINDER WITH DISCRETE FRACTURE INCLINE TO AXIS (WITH OR WITHOUT AXIAL BOREHOLE)		TRIAXIAL TESTS, CONSTITUTIVE PROPERTIES OF JOINTS, FRACTURE CONDUCTIVITY
PERVASIVELY FRACTURED CYLINDERS (WITH OR WITHOUT AXIAL BOREHOLE)		TRIAXIAL TESTS, ROCK MASS CONSTITUTIVE PROPERTIES, THERMOMECHANICAL BEHAVIOR, ROCK MASS PERMEABILITY, DOWN HOLE GEOPHYSICS

Table 2. Factors Influencing Techniques Used for Recovery of Large Specimens of Rock.

	PURPOSE OF TEST	LOCATION OF ROCK TO BE SAMPLED	FRACTURES AND DISCONTINUITIES	SPECIMEN GEOMETRY
TREND OF INCREASING COST AND DIFFICULTY OF SAMPLING ⇩	RESEARCH (ANY SOURCE OF SUITABLE ROCK)	AT SURFACE	UNFRACTURED (INTACT)	
		IN QUARRIES OR OPEN EXCAVATIONS		
	SITE SPECIFIC ROCK MASS PROPERTIES		SINGLE FRACTURE	CYLINDRICAL
		IN UNDERGROUND ENTRIES		CUBIC OR PRISMOIDAL
	SITE SPECIFIC PROPERTIES OF LOCALIZED GEOLOGIC FEATURES (EG JOINTS)	IN DEEP SHAFTS	PERVASIVELY FRACTURED	

Factors Influencing Sampling Procedures

When selecting procedures to be used to extract samples from the parent rock mass, careful consideration must be given to the specific type and purpose of the laboratory tests to be performed. However, a number of factors that have a general influence on the practical aspects of specimen acquisition and preparation can be identified. The principal of these are listed in Table 2. The indicated trend of increasing cost and difficulty of sampling is illustrative only. The complexity of the procedure depends upon the combination of factors present in any given situation. For example, large cylinders of intact rock suitable for general phenomenological research can be cut from blocks of material excavated during routine quarrying operations. These blocks may be reduced to cylindrical form using wire saws and rock dressing equipment available at the site. In situations where undisturbed specimens of jointed rock, say, from the wall of a small tunnel are required, the sampling procedures are normally much more complex. In such cases, restricted access may prevent the use of heavy equipment. The specimens are also susceptible to damage during sampling, transport and handling in the laboratory, particularly when the rock mass is pervasively fractured. Thus, a one hundred percent success rate in sample recovery cannot be expected and equipment and procedures must frequently be modified to meet the specific conditions encountered in the underground.

Sampling Methods and Specimen Preparation

Core drilling for large rock specimens is possible only in those cases where the sampling site is accessible to heavy equipment. A large calyx core barrel and a 0.95 m diameter granite core are shown in Figs. 1 and 2. Large blocks of rock can be cut from quarries and open excavations by several

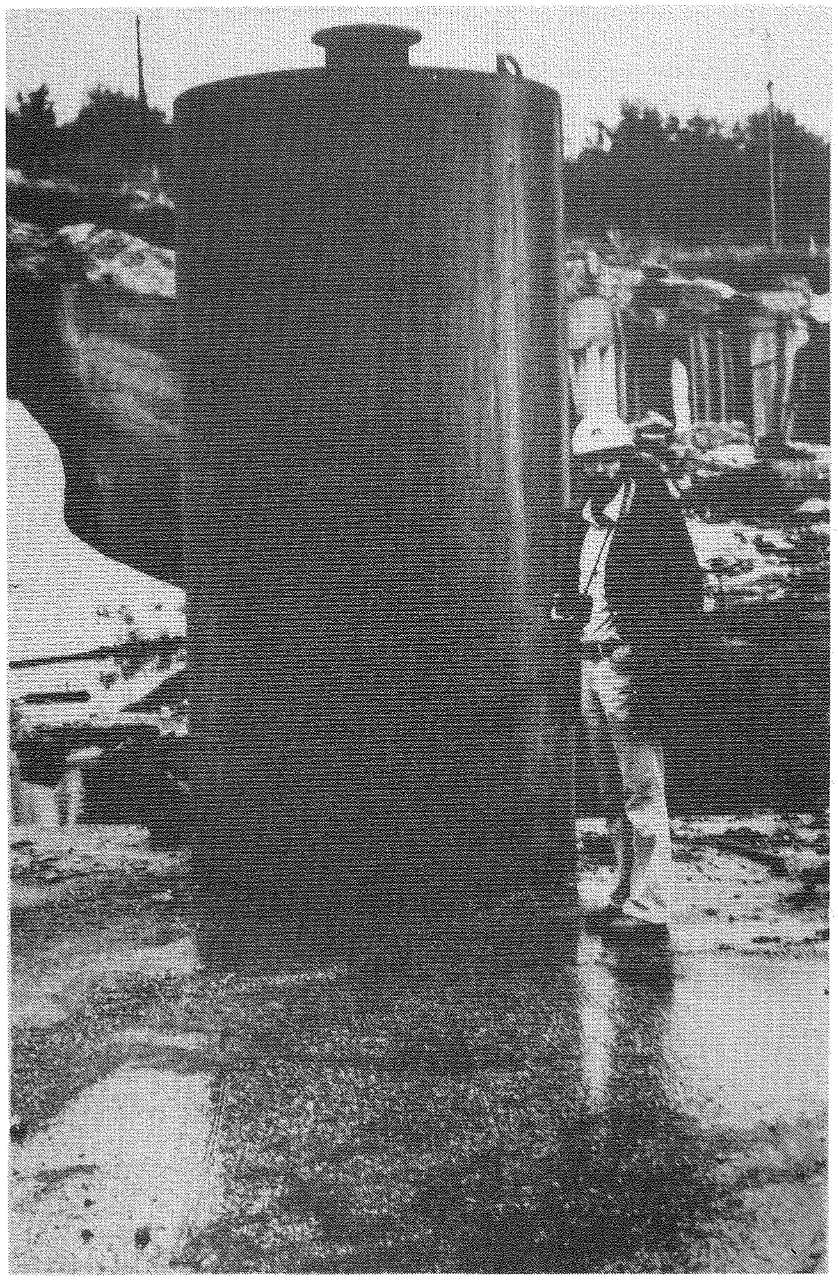


Fig. 1. Calyx core barrel.
(CBB 7911-15315)

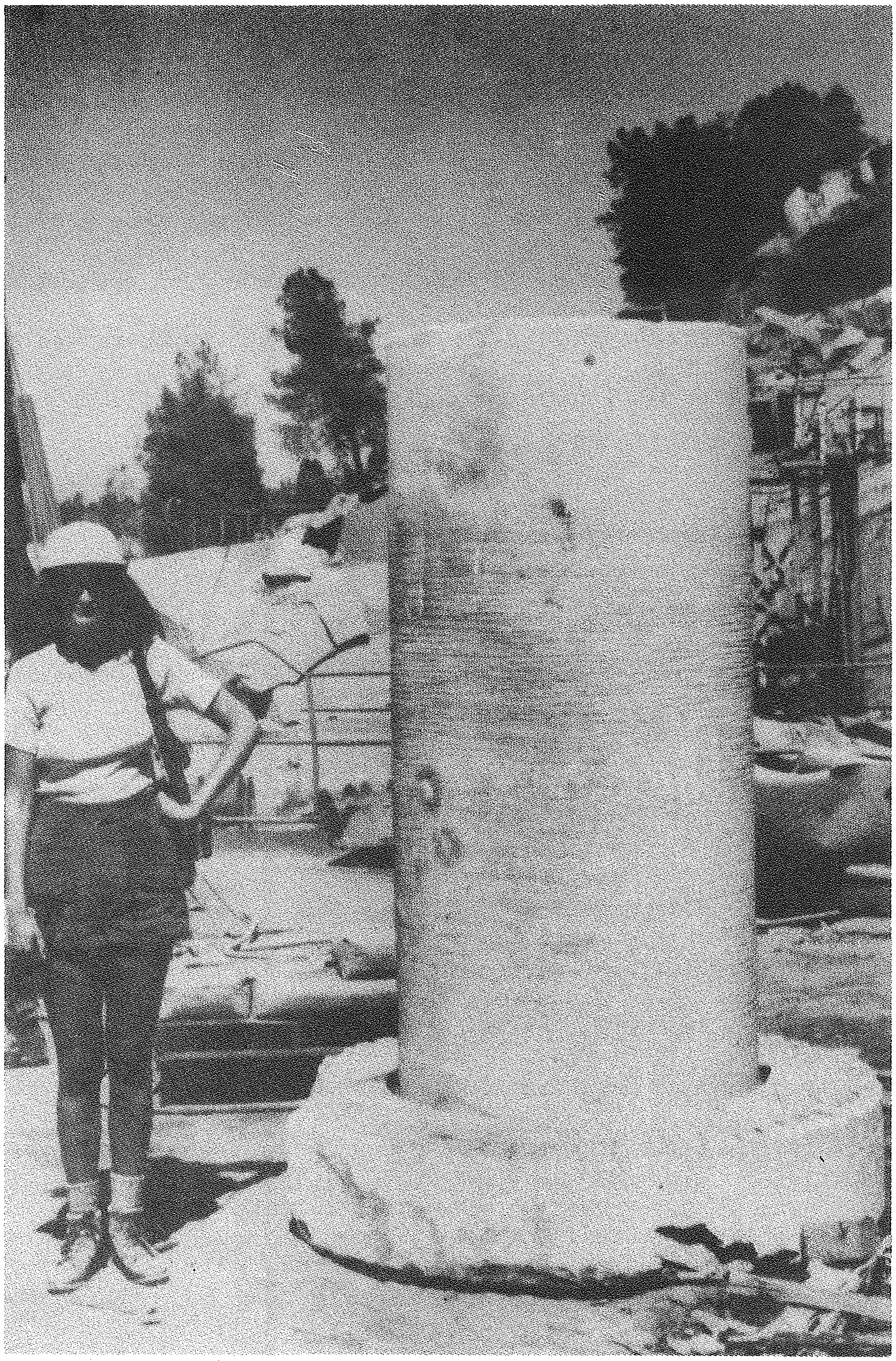


Fig. 2. 0.95 m diameter granite core
(XBB 8012-15038)

methods. Commonly-used techniques include presplitting and blasting, flame cutting, splitting with feather wedges, and wire sawing using carborundum grit. Test specimens of the required geometry can be cut from rough blocks with rock saws and shaped on wire saw jigs and by grinding on large lathes. When these methods can be applied, specimens with smooth surfaces and flat parallel ends can be obtained. This is a major advantage when specimens are to be used in triaxial testing machines or similar apparatus where the end conditions are critical or when the rock must be encased in a flexible membrane.

When specimens have to be cut from the walls of underground openings, and in other situations where special equipment is not available, slot drilling techniques are usually used. A slot is cut around the perimeter of the specimen and the base is then broken away from the parent rock. This may be done by driving wedges into the perimeter slot, however, when the rock is jointed or fractured and susceptible to sampling disturbance it may be necessary to completely undermine the specimen. Samples obtained in this way have rough surfaces and must be finished in the laboratory before instruments can be installed and the specimen tested. Smooth, parallel loading surfaces are usually required and are provided by construction of end caps formed from high strength or reinforced concrete, cement grouts or steel filled epoxy.

An advantage of large specimens is the number of instruments that can be mounted on them. This permits much more detailed data to be gathered than is possible from small samples. Typical specimen instrumentation includes linear variable differential transformers (LVDTs) strain gauges, piezometers, and thermocouples. LVDTs, used to measure deformations, are mounted on the rock by anchor posts set in holes drilled into the rock or glued to the surface. Thermocouples and piezometers can be installed in small diameter holes located such that internal distribution of temperature and pore fluid pressure can be monitored.

Examples

Two examples of very large rock specimens serve to illustrate some of the sample acquisition and preparation techniques that can be used. Figure 3 shows a 0.94 m diameter by 1.5 m high cylindrical specimen of pervasively fractured granitic rock recovered from the rib of an entry in an iron ore mine at Stripa, Sweden. Its dimensions are shown in Fig. 4. This specimen was used to study the unconfined compressive strength and deformation properties of the rock and to investigate the relationship between stress and rock mass permeability. The axis of the specimen was oriented approximately horizontally in the wall of the underground opening. The specimen was freed from the rock mass using a slot drilling technique (Andersson and Halén 1978). A pilot hole was first drilled through the axis of the specimen and a rock bolt installed to apply a compression load to minimize disturbance to the fractured rock. A series of 51 mm percussion drilled holes was then made around the perimeter of the specimen using a specially adapted drill equipped with a jig and guide bars located in the central pilot hole and in each successive peripheral hole. The specimen was broken from the rock mass by pulling axially until the bottom separated at a pre-existing discontinuity. Figure 5 shows the resulting hole in the rib and the specimen enclosed in a steel cage for shipping to the laboratory. On arrival, the sample was prepared for testing by capping both ends with reinforced concrete and instrumenting with LVDTs and strain gauges to measure macroscopic and fracture deformation response under axial loading.

Fig. 3. Large specimen of fractured granitic rock.
(CBB 796-8236)

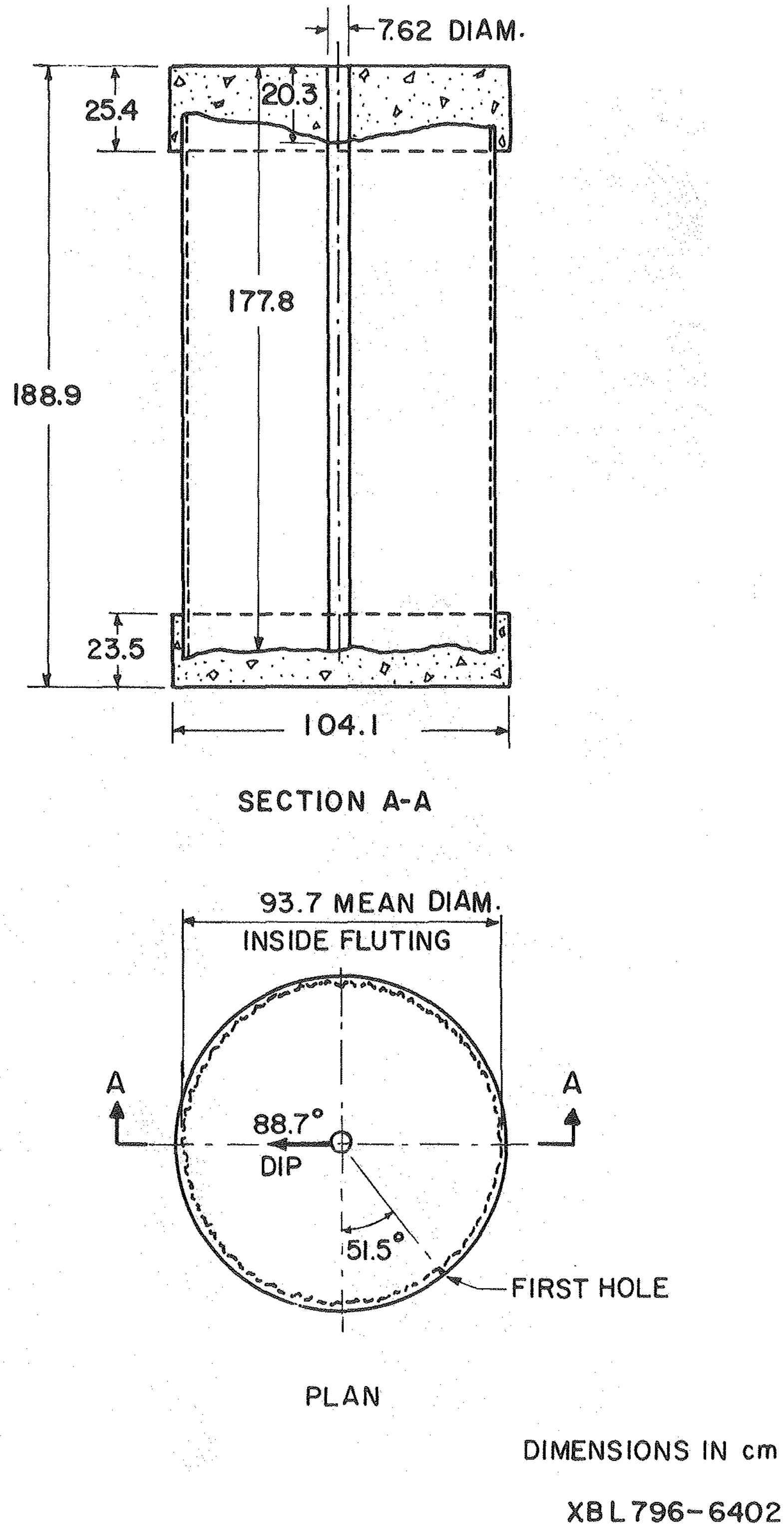


Fig. 4. Dimension of granitic specimen.

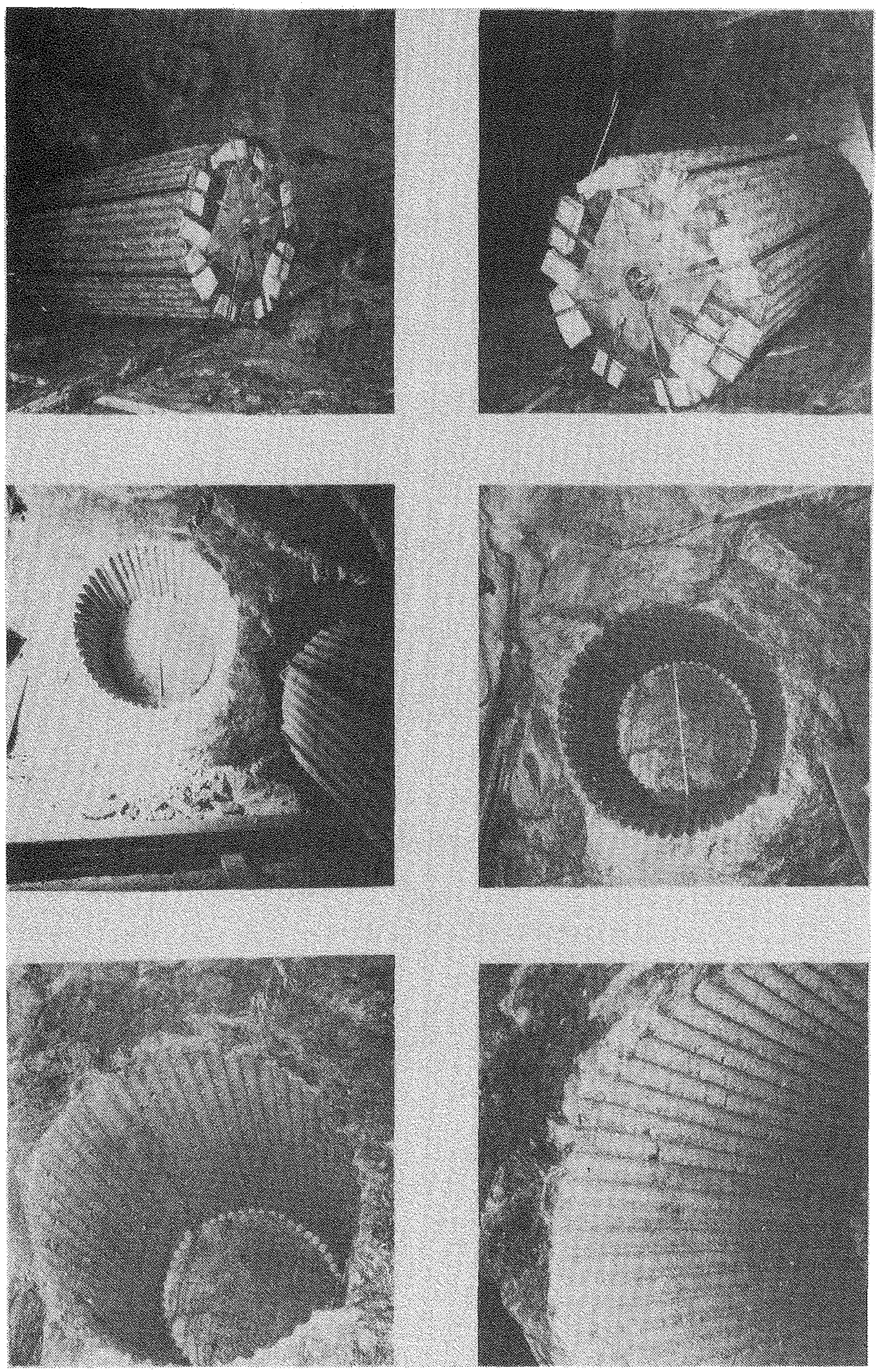


Fig. 5. Granitic specimen as recovered from rib of mine entry.
(XBB 788-10480)

A second example illustrates a situation where specialized rock dressing equipment was available at the sampling site. In this case a cylindrical specimen containing a single natural fracture oriented normal to the long axis was required for research on fracture conductivity. A large block of granite (see Fig. 6) containing a suitable fracture was located at the Charcoal Black quarry near St. Cloud, Minnesota. To avoid disturbance to the fracture a steel compression bolt was installed through the center of the block before it was reduced in size and formed into a cylindrical specimen, 0.91 m in diameter by 1.83 m high, using wire saws. The sawing equipment is shown in Figs. 7 and 8. Only limited additional work was required to prepare the specimen for testing and LVDT and strain gauge instrumentation (see Fig. 9) could be mounted with minimal preparation of the surface. Figure 10 shows the specimen being enclosed in the vessel of the large triaxial machine that was used to test the rock under unconfined axial compression.

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Thorpe, R., Watkins, D. J., Ralph, W. E., Hsu, R. and Flexser, S., 1980. Strength and Permeability Tests on Ultra-Large Stripa Granite Core. Lawrence Berkeley Laboratory, Berkeley, California 94720. LBL-11203, SAC-31.

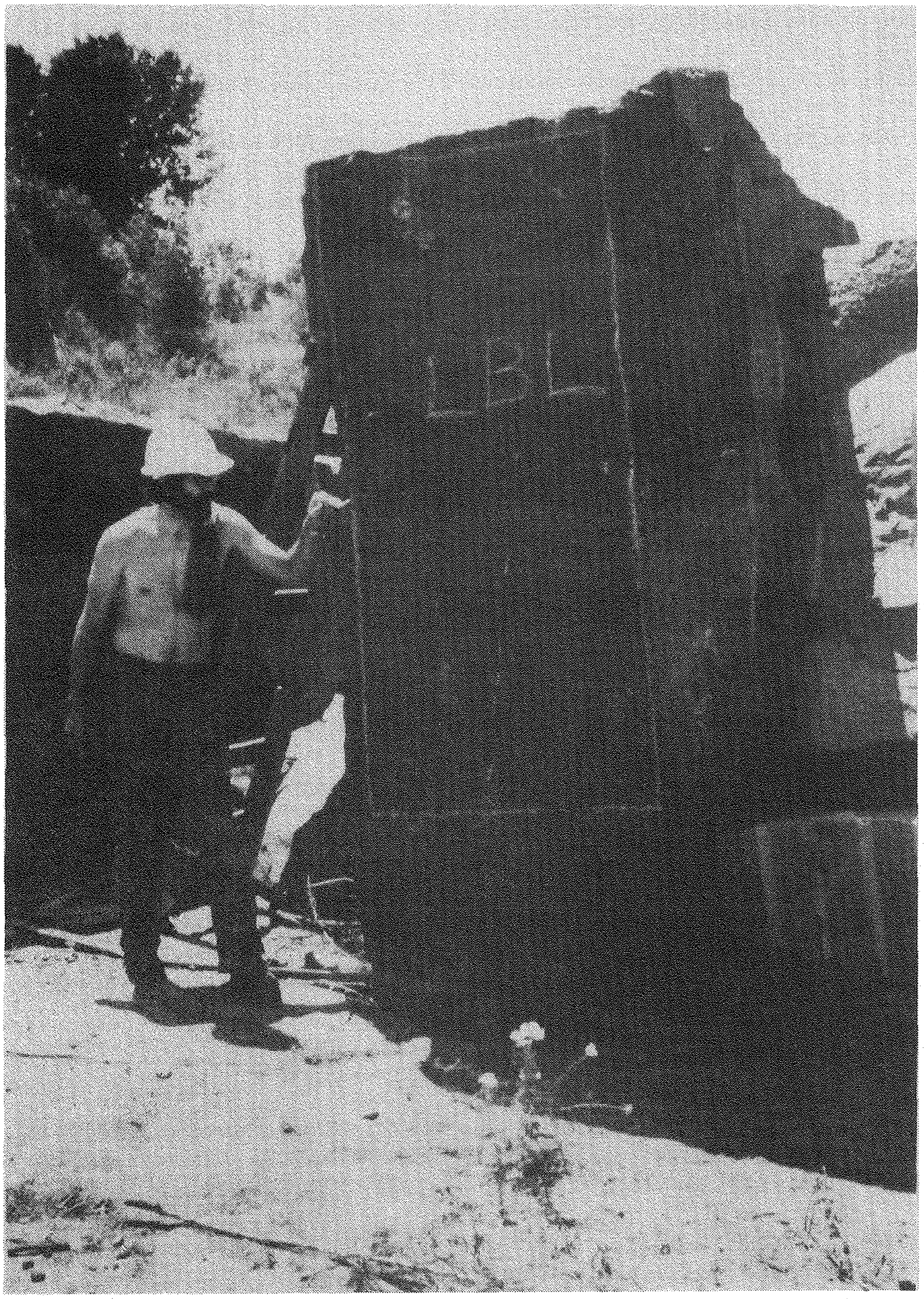

Fig. 6. Fractured block of Charcoal Black granite.
(CBB 798-10084)

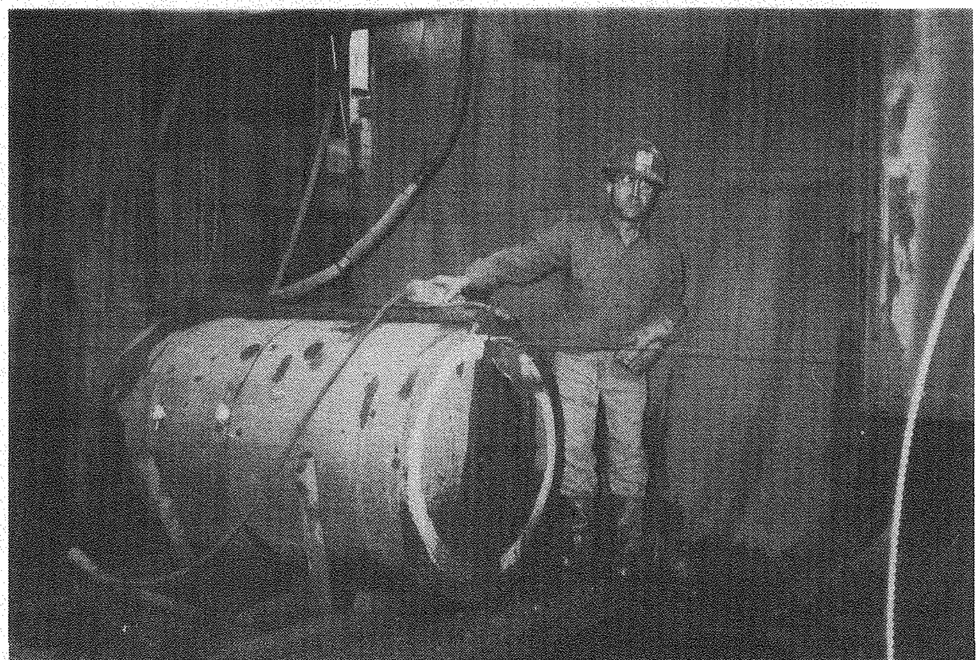

Fig. 7. Cutting granite specimen with wire saw.
(Photo courtesy of Cold Spring Granite Co.)
(XBB 8012-150390

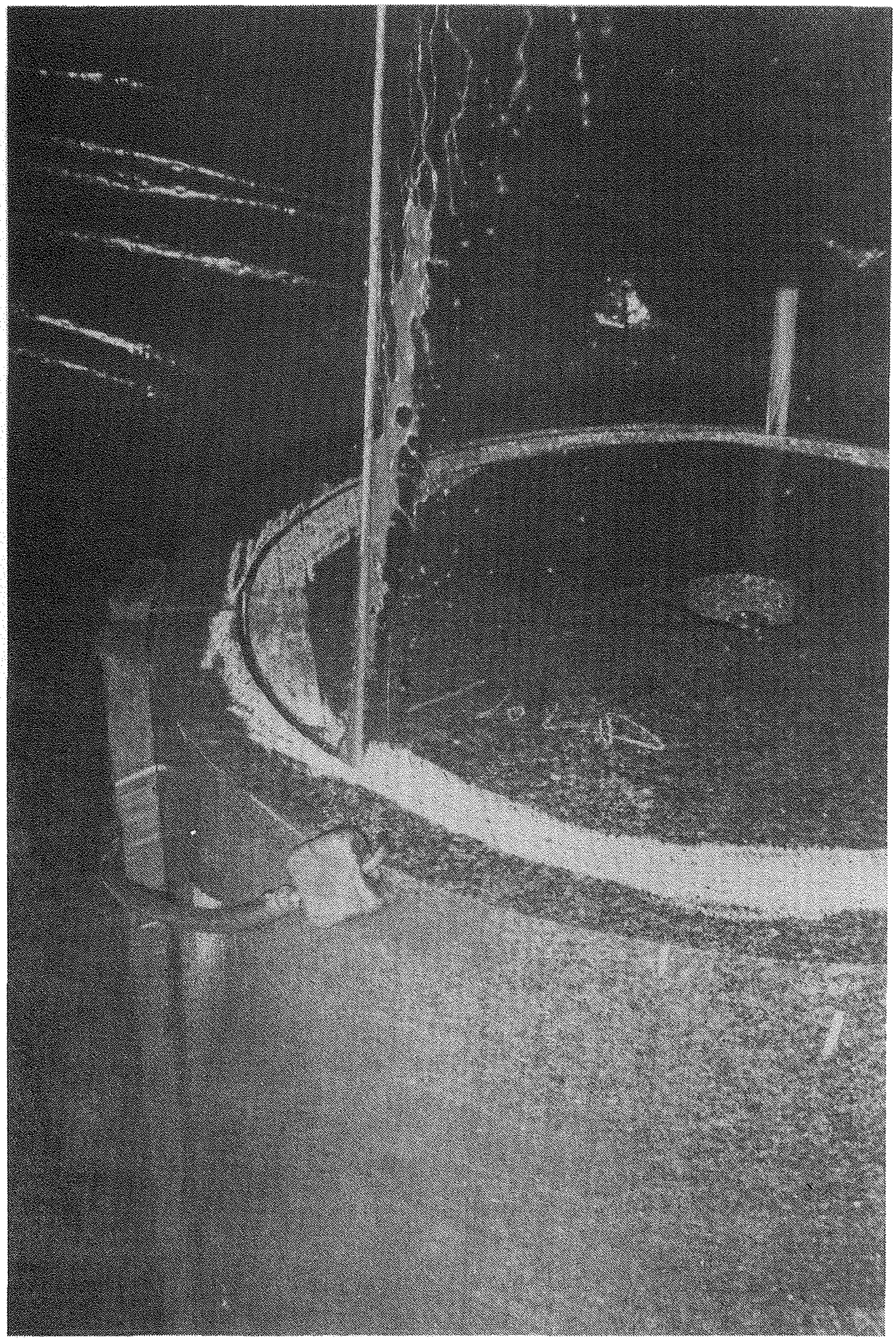

Fig. 8. Detail of wire saw cut.
(Photo courtesy of Cold Spring Granite Co.)
(XBB 8012-15040)

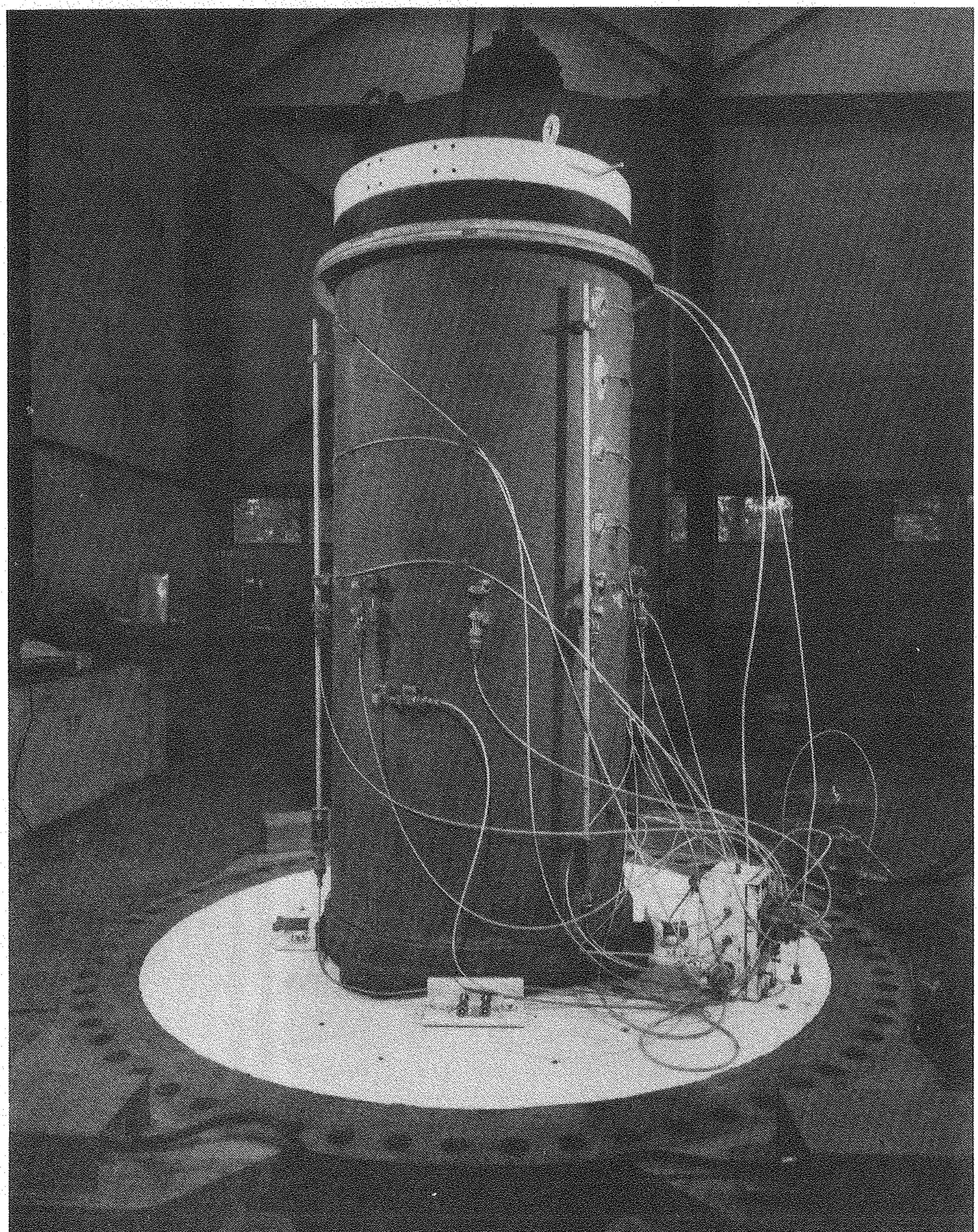

Fig. 9. Instrumented specimen of Charcoal Black granite.
(CBB 800-11823)

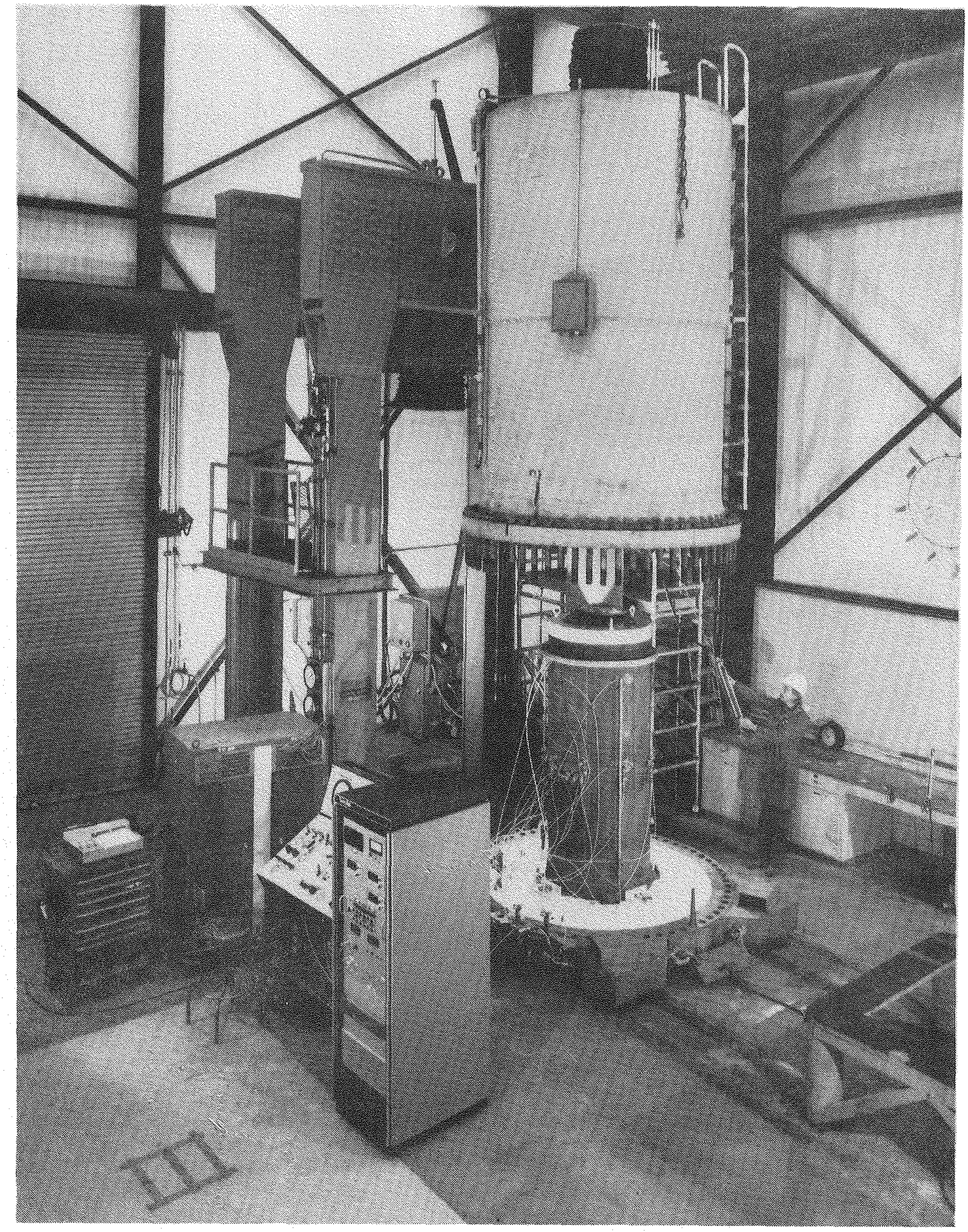

Fig. 10. Large specimen of Charcoal Black Granite set-up in testing machine.

(CBB 800-11819)